

# Environmental Protection Agency

## **Heavy-Duty Diesel Engine Break-in Procedure**

This procedure is written for the Environmental Protection Agency, National Vehicle and Fuel Emissions Laboratory (NVFEL) internal use. The use of specific brand names by NVFEL in this procedure are for reference only and are not an endorsement of those products. This document may be used for guidance by other laboratories.

### **NVFEL Reference Number**

753C

### **Implementation Approval**

Original Procedure Authorized by EPCN #119 on 12-21-92

### **Revision Description**

- (1) 11-20-95 The purpose of this change is to revise the procedure as described in EPCN #177.

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**1. Purpose**

The purpose of the heavy-duty diesel engine break-in process is to facilitate the dimensional and functional stabilization of engine components. The necessity of the engine break-in is determined by the Project Officer.

**2. Test Article Description**

Diesel engines submitted for testing to the Environmental Protection Agency (EPA) Testing Services Division (TSD) Heavy-Duty Engine Testing (HDET) with no prior usage or engines requiring break-in as specified by the Project Officer. This procedure especially applies to engines defined as heavy-duty engines in the Code of Federal Regulations.

**3. References**

- 3.1 Environmental Protection Agency (EPA) current safety policies
- 3.2 "Cellmate II Operations Manual"

**4. Required Equipment**

- 4.1 Form 751-01, "HDET - Engine and Test Specification," (see TP 751)
- 4.2 Form 753-01, "HDET - Diesel Engine Break-In," (Attachment A)
- 4.3 Electric Engine Dynamometer  
Equipment used: GE, Model 42 G 408 AD
- 4.4 Throttle Amplifier  
Equipment used: Digalog Model TC
- 4.5 Throttle Actuator  
Equipment used: Foxboro-Jordan Model MC 10596
- 4.6 Test cell temperature monitoring system  
Equipment used: Laboratory standard type "J" thermocouple (minimum 15 required)  
Molytek Model 2702 microprocessor-based strip chart recorder

4.7 Dynamometer torque and speed display instruments

Equipment used: Daytronic Signal Conditioners:  
Model 9178A, Strain Gage Conditioner (2 required)  
Model 9140, Frequency-to-voltage Conditioner (2 required)  
Model 9515A, Digital Indicator (4 required)

4.8 Constant Volume Sampler (CVS) Compressor Unit (Blower)

Equipment used: Spencer Turbine Turbo Compressor, Model 2060 HMOD

## 5. Precautions

- 5.1 A person must remain in the control room at the dynamometer console during engine operation, in position to activate the “EMERGENCY STOP” button if a potentially hazardous situation arises.
- 5.2 No personnel are allowed in the test cell while the engine is in operation, except to perform adjustments or tests which specifically require their presence at that time.
- 5.3 Any person entering the test cell during engine operation must wear hearing protection, safety glasses, and safety shoes. This person must stay out of line with rotating engine and drive shaft components as much as possible.
- 5.4 The engine must be checked for hydrostatic lock. Hydrostatic lock is a condition which results from an incompressible fluid collecting in a cylinder to the extent that its volume is greater than the total volume of the combustion chamber when the piston is at top dead center. If fluid exists in the chamber at this time, the piston may not be able to complete its upward stroke and serious damage to the engine can occur if the dynamometer is turning the engine.

Prior to starting the engine, the engine crankshaft is manually turned at least two revolutions prior to operation to ensure that conditions of hydrostatic lock do not exist. The direction of engine rotation is recorded on Form 751-01.

- 5.5 If the exhaust is connected to the CVS unit, the “EXHAUST SELECTION VALVE” must be set to the “CELL 2” position.
- 5.6 The engine oil must be checked prior to every engine start and, if any is added, the amount must be recorded on Form 753-01.
- 5.7 The dynamometer “SPEED” and engine “THROTTLE” controls must be rotated fully counterclockwise to zero before activating the control panel.

- 5.8 The “ENGINE SPEED SAFETY LIMITER” must be set to 100 rpm above the maximum safe engine speed.

## 6. Visual Inspections

Visual inspection of the engine and dynamometer set-up is conducted prior to starting the engine. Instructions for specific inspections are covered in Section 7, Test Article Preparation.

## 7. Test Article Preparation

- 7.1 On both pages of Form 753-01, record the “Engine Identification” and “Test Number.”
- 7.2 On Form 753-01, under the “Pre-Startup Inspections and Adjustments,” section, perform the following inspections and adjustments and put a check mark in the appropriate line corresponding to each step.
- 7.2.1 Use the spanner wrench and manually rotate the drive shaft two full revolutions, in the direction of normal rotation, to ensure that conditions of engine hydrostatic lock do not exist.
- If hydrostatic lock conditions exist during the manual rotation operation, notify the HDET Supervisor.
- 7.2.2 The exhaust is routed to the scrubber. If not enter “NA.”
- 7.2.3 If the exhaust is connected to the CVS, ensure that the “EXHAUST SELECTION VALVE,” located on the ceiling in Room 413A, is in the “CELL 2” position. If not connected to the CVS, enter “NA.”
- 7.2.4 Check the engine oil level. If the oil level is not sufficient, add the appropriate amount. On Form 753-01, record the amount of oil added.
- 7.2.5 Drain the fuel/water separator, if the engine is so equipped. Enter “NA” if there is no separator.
- 7.2.6 Fill the cooling tower with water until the sight gage reads approximately two-thirds full.
- 7.2.7 Open the air valve and water valve on the side of the cooling tower.
- 7.2.8 Connect the fuel supply and return lines to the engine. Ensure that the fuel barrel is at least two-thirds full of fuel before connecting the fuel lines.

- 7.2.9 Connect the coolant supply and return lines to the engine and open the cooling water flow valves at the floor.
- 7.2.10 Secure the drive shaft and torque transducer scatter shields with safety chains.
- 7.2.11 Verify the integrity of all fasteners securing the engine, test stand, and drive components prior to operating the engine.
- 7.2.12 Verify that "AIR HANDLING UNIT #10" is "ON" and that the "VENTILATION CONTROL" switch is in the "TEST" position.  
  
If the air handler is off, notify the building service contractor.
- 7.3 Verify that the AC power is switched to Dyno 2. To verify or change power to the dynos:
  - 7.3.1 Turn the rotating switches on the front of G.E. Cabinet #2 labeled "AC DISCONNECT" and G.E. Cabinet #3 labeled "LINE SWITCH" to "OFF." Switch the circuit breaker on the side of G.E. Cabinet #5 to "OFF."  
  
This step must be completed as a safety requirement to ensure that the power is off when opening the cabinet.
  - 7.3.2 Open Cabinet #3 and check the position of the knife switches.
  - 7.3.3 When the switches are to the right side, Dyno #1 is energized. When they are to the left side, Dyno #2 is energized. Move them to the proper position, if necessary.
  - 7.3.4 Close the cabinet and switch the circuit breaker (Cabinet #5) "ON" and then turn the rotating switches "AC DISCONNECT" (Cabinet #2) and "LINE SWITCH" (Cabinet #3) "ON."
- 7.4 On Form 753-01, record the required total break-in run time (as indicated on Form 751-01).
- 7.5 On Form 753-01, record the "Cumulative Run Time" from the previous break-in session. If this is the first break-in session, record a zero for this time.
- 7.6 On Form 753-01, in the "Break-In Sequence" section, record the required break-in modes specified on Form 751-01.

## 8. Test Procedure

To perform an engine break-in, the dynamometer is prepared for use before any testing begins. The engine will be operated using the specified break-in procedure provided on Form 751-01. Since the times and modes involved may vary with each engine, a general overview is presented here.

### 100 Dynamometer Control Preparation

- 101 Set the "SPEED" and "THROTTLE" controls fully counterclockwise to zero.
- 102 Set the "ENGINE ROTATION" switch to the "CW" (clockwise) or "CCW" (counterclockwise) position. The engine rotation direction is specified on Form 751-01.
- 103 Apply power to the motor/generator (MG) by pressing the green "START" button above the "MG SET" label. The button will illuminate when the MG set is operating. Operating the MG set ensures that the dyno armature is floating on a film of oil.
- 104 Prior to engine start, check the dynamometer sight gage for a regular drip of dynamometer lubricant. Place a check on Form 753-01 if the drip is observed.
- 105 Turn the "POWER" switch to the "On" position.
- 106 Turn the "FUEL / IGN." switch to the "ON" position.
- 107 Press the "RESET" button. A click should be heard, indicating solenoid operation, and the green light labeled "FUEL ON" will illuminate.
- 108 Apply power to the dynamometer by pushing the green DYNA "ON" button. The green button will illuminate, indicating that the dynamometer is ready for use.
- 109 On the dynamometer control panel, locate the yellow "CONTROL" button labeled "MANUAL" and press it three times. The button will illuminate, indicating the dynamometer is in the manual mode.
- 110 Turn on the "THROTTLE CONTROLLER" by pressing the two yellow buttons located on the front panel. The two buttons will illuminate, indicating that the controller is on.

**200 Engine Operation**

- 201 Rotate the “SPEED” control clockwise to achieve the specified idle speed indicated on Form 751-01. On Form 753-01, record the engine start time (use 24-hour clock).

Engine ignition will be confirmed by the torque meter readings approaching zero from negative values. If ignition is not observed, turn the “SPEED” control back to zero and notify the HDET Supervisor. Do not attempt to restart the engine without proper authorization.

- 202 Adjust the dynamometer speed and engine throttle controls to achieve the desired speed and load conditions, as indicated on Form 751-01, for each mode of the break-in procedure.

**Note:** If for any reason the engine is stopped during operation of a break-in, follow the specified warm-up procedure on Form 751-01 when restarting.

- 203 On Form 753-01, under the “Break-In Sequence” section, record the “Mode Start Time” and at the end of the mode record the “Mode End Time.”

- 204 Calculate the total time in the mode and record that value under the “Time in Mode” header.

- 205 Repeat Steps 203 and 204 for the remain required modes and record the data in the corresponding spaces.

- 206 At the completion of the cool-down mode, bring the engine to a stop by returning the “SPEED” and “THROTTLE” controls to zero simultaneously.

On Form 753-01, record the engine shut-down time (use 24-hour clock).

- 207 On Form 753-01, complete the “Time Checks” section.

If the “Total Break-in Completed” time is greater than or equal to the required “Required Break-in Time,” the engine break-in process is complete.

If it is not, continue the break-in process.

- 207 Sign and date Form 753-01.

- 208 Turn the “POWER” switch on the dyno control panel to “OFF.”



209 Turn the “FUEL / IGN.” switch to “OFF.”

210 Press the M.G. Set “STOP” button.

## **9. Data Input**

9.1 The results of the engine set-up, visual inspection, and run mode times are recorded on Form 753-01.

9.2 Engine oil, ambient, and cooling water temperatures are recorded by the Cellmate II computer.

## **10. Data Analysis**

10.1 A technician that did not record the data, reviews Form 753-01 for completeness.

10.2 A technician that did not record the data, reviews the mode times on Form 753-01 and verifies that the calculations are correct. If correct, they sign and date the form. If corrections are required, they return the form to the technician that performed the process.

## **11. Data Output**

11.1 Form 753-01 is completed for each break-in session and is placed in the test packet labeled with the corresponding “Engine Identification” and “Test Number.”

11.2 The test packet is sent to the Project Officer upon completion of engine testing.

## **12. Acceptance Criteria**

12.1 The “Cumulative Break-in Time” meets the required engine break-in time indicated on Form 751-01.

12.2 The engine break-in adheres to specified warm-up, run, and cool-down modes.

12.3 The coolant temperature is verified to be within the specified tolerances indicated on Form 751-01.

- 12.4 The engine oil temperature is verified to be within the specified tolerances indicated on Form 751-01.

### **13. Quality Provisions**

- 13.1 Engine oil consumption is monitored by recording the amount of oil added to the engine on Form 753-01.
- 13.2 The total engine run time between oil level checks is 8 hours or less.
- 13.3 The engine speed is limited by setting the “ENGINE SPEED SAFETY LIMITER” to 100 rpm above the maximum safe engine speed specified on Form 751-01.

Attachment A  
**HDET - Diesel Engine Break-in**

**Engine Identification:** \_\_\_\_\_ **Test Number:** \_\_\_\_\_

**Pre-Startup Inspections and Adjustments**

Verify the following:

- \_\_\_\_\_ Engine crankshaft manually rotated two revolutions
- \_\_\_\_\_ Exhaust connected to scrubber
- \_\_\_\_\_ Exhaust connected to CVS and "EXHAUST SELECTION VALVE" in "CELL 2"
- \_\_\_\_\_ Engine oil level OK; if not, record amount added \_\_\_\_\_
- \_\_\_\_\_ Fuel/water separator drained (or NA)
- \_\_\_\_\_ Cooling tower water level OK
- \_\_\_\_\_ Air and water tower valves open
- \_\_\_\_\_ Fuel barrel at least  $\frac{2}{3}$  full
- \_\_\_\_\_ Coolant valves open
- \_\_\_\_\_ Drive shaft and torque transducer shields secured
- \_\_\_\_\_ Integrity of all fasteners verified
- \_\_\_\_\_ Test cell power set to "DYNO 2"
- \_\_\_\_\_ Air handler "ON" and in "TEST" mode
- \_\_\_\_\_ Dyno lubricant level OK

I have performed the steps in accordance with the requirements of Test Procedure 753.

Technician's Name: \_\_\_\_\_ Date: \_\_\_\_\_

The data entries are accurate and meet the requirements of Test Procedure 753.

Verified by: \_\_\_\_\_ Date: \_\_\_\_\_

Attachment A Continued  
**HDET - Diesel Engine Break-in**

**Engine Identification:** \_\_\_\_\_ **Test Number:** \_\_\_\_\_

**Break-In Sequence**

Record the mode start and end times, then calculate the actual time in each mode. All times must be recorded using a 24-hour clock.

Speed (rpm)	Load (% max.)	Torque (lb-ft)	Required Mode Time (hour:min)	Mode Start Time (hour:min)	Mode End Time (hour:min)	Time in Mode (hour:min)
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
Cumulative Time						_____

**Time Checks:**

- \_\_\_\_\_ 1. Record the "Cumulative Time" from any previous Form 753-01 for this engine.  
If there is no previous Form 753-01 for this engine, enter 0 (zero)
- \_\_\_\_\_ 2. Total Break-in Completed.  
Add the "Cumulative Time" from this form to the value in #1.
- \_\_\_\_\_ 3. Required Break-in Time

Compare value in #2 to the value in #3. If the value in #2 is greater than or equal to the value in #3, the required engine break-in time has been met. If not, continue the break-in process.

Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

I have performed the steps in accordance with the requirements of Test Procedure 753.

Technician's Name: \_\_\_\_\_ Date: \_\_\_\_\_

The data entries are accurate and meet the requirements of Test Procedure 753.

Verified by: \_\_\_\_\_ Date: \_\_\_\_\_